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Validation Study of Roughness Effect on Full-scale CFD Prediction of a Self-propelled Tanker for Straight Run and Zigzag Maneuvering

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ABSTRACT

Full-scale ship CFD prediction are on increasing interest throughout the world. Surface roughness significantly influences the hydrodynamic performance of ships, particularly at full-scale, where its effects are more pronounced. There have been many studies on the effect of roughness on varying scale as well as full-scale ship performance prediction using CFD. However, due to the lack of real sea trial data, a very few numbers of studies have been conducted on the validation. Mikkelsen and Walther (2020) did validation study on the effect of roughness in full-scale ship resistance prediction for a ro-ro vessel and a general cargo vessel. Sakamoto et al. (2020) investigated the capability of viscous CFD, with surface roughness embedded in the turbulence model, to simulate a free running maneuvering for a tanker in full-scale and validated against sea trial data. Recently, Matsuda and Katsui (2024) determined an optimal roughness length scale for full-scale ship CFD simulation by aligning the computed wake distribution with Ryuko-maru's full-scale measured data.

This study investigates the impact of hull roughness on the full-scale ship CFD prediction for a tanker. Validation study has been carried out against the sea trial data under realistic operational conditions. CFD simulations were performed based on the unsteady Reynolds-averaged Navier-Stokes (URANS) equations of FINE/Marine software. At first, extensive CFD validation study was performed in model scale for both full load and ballast conditions at different rudder angle. Then self-propulsion simulation at full-scale was performed with and without roughness model. Body force propeller model was used for the propeller thrust. Full-scale Zigzag maneuvering simulation was also performed with and without roughness model. All the full-scale CFD simulation results were compared to the sea trial measurements. The findings reveal that surface roughness can lead to substantial deviations in full-scale ship CFD predictions, emphasizing the need for accurate roughness modelling in full-scale simulations. This study shows how proper roughness modelling can improve the accuracy of full-scale CFD prediction both in straight run and Zigzag maneuvering conditions.

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